SERVICE MANUAL

FOR

MODEL 3600

POWER LINE DISTURBANCE MONITOR

Franklin Electric
Programmed Power Division

Figure 1-1. Model 3600 Power Line Disturbance Monitor

SECTION I
GENERAL INFORMATION

1.1 DESCRIPTION

The Model 3600 Power Line Disturbance Monitor™ (Figure 1-1) is a portable, multipurpose instrument used to monitor disturbances on three-phase AC and one-channel DC power lines. It monitors AC voltages in the 50 to 800 volt range and DC voltages in the 0 to 20 volt range. A microprocessor and semiconductor memory are used to detect, process, analyze, and classify disturbance data. A microcomputer provides character generation and control for the alphanumeric printer. The monitor has a remote monitoring capability via the RS232-compatible interface.

Detected disturbance data are classified as overvoltages, undervoltages, pulses (fast transients), low frequency, high frequency, and three-phase undervoltages and overvoltages. Precise thresholds are preset by keyboard data entry. When disturbances exceed the preset thresholds, they are measured for amplitude and duration. An alphanumeric printout identifies the disturbance and the channel of occurrence, the time of the occurrence, the duration in microseconds, milliseconds or seconds, the voltage amplitudes, and the frequency variations. At midnight, a status and disturbance summary printout occurs automatically. A summary can be printed at any time by depressing the STATUS PRINT key on the front panel.

The monitor implements a new measurement technique called Post Threshold Tracking™. A voltage disturbance exceeding a precise threshold setting is automatically tracked for the entire period that it exceeds the threshold. The voltage is sampled every 10 milliseconds. A new amplitude printout occurs whenever the disturbance voltage varies by more than approximately 3% of the undervoltage threshold. The printout occurs no more frequently than every 30 seconds. Exact levels and times of occurrence data permit close tracking of the disturbance, whether it is of short or long duration.

The Model 3600 monitor provides several special and unique features that enhance the capabilities of the instrument. The instrument has a wide dynamic AC range and therefore the operator does not have to keep track of any attenuation values. The printouts are easily interpreted because of the logical order of the formats. The Display Select switch and the associated LED function display provide an easy means of monitoring the input frequency and the input voltages. The switch and display also provide an easy means of selecting the threshold and time/date values to be entered. The internal calibrator circuitry allows the user to verify the proper function of each channel and provides precise calibration of the monitor. The calibration function can be used at any time during normal operation. The internal uninterruptible power supply (UPS) and the external UPS capability allow the monitor to be operated during periods of power instability. The RS232 interface capability allows the monitor outputs to be remotely displayed on an external device. The outputs can then be correlated with other external events. The internal printer can be disabled to allow high speed data transmission not limited by printer speed.

1.2 MEASUREMENT DESCRIPTION

The details of the measurement techniques used in the monitor are described in this section. This description enables the user to better understand the basic measurement techniques used by the monitor, and also to better interpret the various data printouts.

1.2.1 OVERALL MEASUREMENT METHOD

The AC and DC inputs to the monitor are each applied to analog conditioning circuitry. The circuitry provides scaling, filtering, and other signal processing to make the signals suitable for sampling and conversion to digital data to be analyzed by the microprocessor. Each of the conditioned signals is sampled every 10 milliseconds, except for pulse signals, which are sampled every 30 milliseconds. Once the signals are sampled and converted to digital data, the digital data is stored by the microprocessor memory for analysis.

It is important to understand that the sampling rate of the microprocessor and the amount of data memory included in the monitor are determining factors in the amount of preconditioning that is required by the analog circuitry and the amount of data manipulation that can be achieved by the microprocessor. The signal preconditioning by the analog circuitry is implemented in hardware and the data manipulation by the microprocessor is implemented in software. The hardware implementation cannot be modified without changing the design of the circuitry. The software implementation can be modified by replacing the programmable memory in the microprocessor. The programmable memory integrated circuits are installed in sockets to allow the possibility of updating or providing customized performance. A simplified block diagram of the measurement function is shown in Figure 1-2.

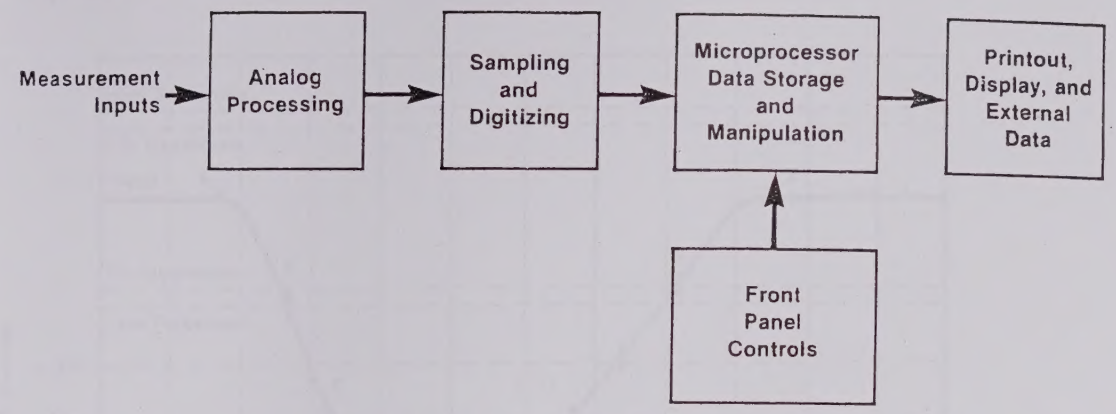

Figure 1-2. Simplified Block Diagram of Measurement Function

1.2.2 UNDER AND OVERVOLTAGE MEASUREMENT

Three independent circuits are utilized to condition the AC phase voltages for analysis by the microprocessor. The combined output of these three circuits is used for the three phase power measurement. The measurement inputs are attenuated by a factor of 500 so that signal levels in excess of 2000 volts can be handled by the analog circuitry. The attenuated signal is filtered to eliminate unwanted signals that are far removed from the line frequency. The signal is then full-wave rectified and applied to a low pass filter with a 10-millisecond time constant. This 10-millisecond filter in combination with the 10-millisecond digital sampling rate limits the response time of the under and overvoltage measurement. Voltage disturbances that last for a duration several times longer than 10 milliseconds will be recorded with an amplitude accuracy approaching ± 1% and a duration accuracy of ± 10 milliseconds. However, a disturbance that lasts only 10 milliseconds, if it is a large disturbance, will be detected, but the duration recorded could be 10 to 20 milliseconds and the level could have an error of as much as 50%. Even though the AC phase voltages are continuously sampled every 10 milliseconds, no printout will occur unless the level has deviated beyond the selected under/overvoltage threshold settings. The exception to this is the status printout initiated manually or automatically once every 24 hours. Once the voltage exceeds a threshold setting, the following operations take place:

1. Level is monitored to determine the maximum deviation.
2. The duration that the threshold is exceeded is recorded.
3. During extended deviations, the level is tracked using the Post Threshold Tracking technique.

Figure 1-3 and the following discussion describe Post Threshold Tracking and help in understanding the basic measurement.

The threshold levels are accurately set into memory by keyboard data entry and verified by the LED digital display. An alarm condition is initiated when the measured value of an input exceeds its threshold limit; this results in an alarm printout. The voltage is then tracked by making measurements every 10 milliseconds. A printout of the voltage level is initiated each time the level changes approximately 3% of the threshold level, except that the printout will not occur more rapidly than once every 30 seconds. This tracking continues for as long as the threshold is exceeded and provides an actual level recording for long term abnormal line conditions. This tracking feature can be forced into operation by setting the threshold levels close to the nominal voltage level so that small excursions will exceed the threshold limits.

The example in Figure 1-3 is for an undervoltage, but the same process occurs for an overvoltage. The following points are identified in Figure 1-3.

A. Nominal line voltage (average value of the sinewave input).
B. Line voltage exceeds threshold setting. Printout at this time will indicate undervoltage alarm and time.
C. The line voltage changed by more than 3% of the threshold setting. A printout of the level and time will occur at each of these times. Notice that the first three printouts labelled C are delayed from the actual 3% level crossings because of the 30-second limit on printout speed. (This limit on printout speed is an arbitrary choice to reduce excessive printout and paper usage and not because of any inherent response time of the monitor.)

D. The line voltage recovered t ithin the threshold limit plus a 1% hyster s. At this time a printout will indicate the time of recovery and the maximum previous line e. ursion at point E.
E. The line voltage reached its lowest level. This value is printed out at time D.

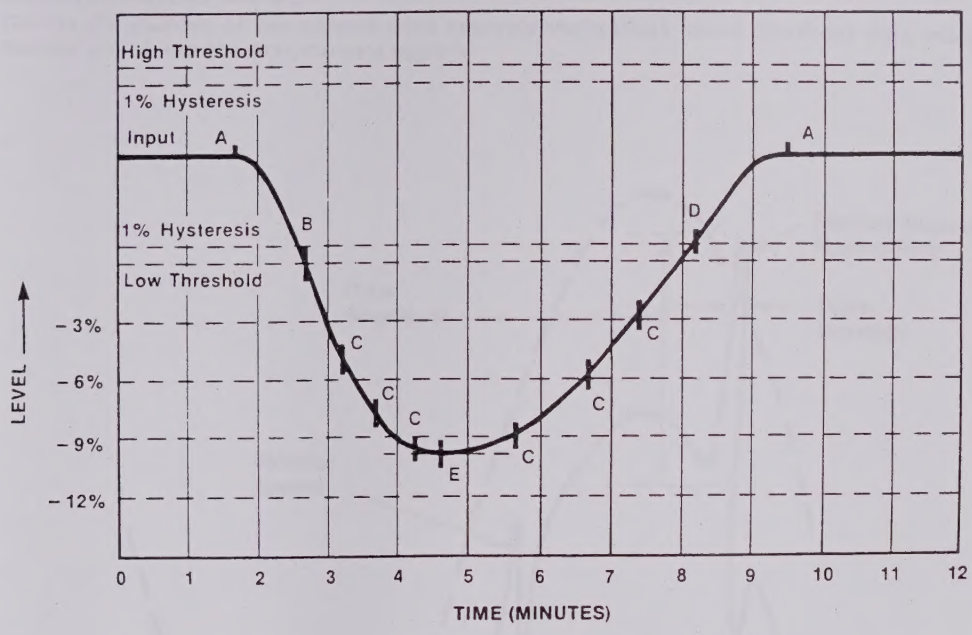

Figure 1-3. Undervoltage Disturbances with Post Threshold Tracking

1.2.3 THREE PHASE MEASUREMENT

The three phase measurement is accomplished by combining the single phase measurements so that the output is equivalent to a three-phase rectified signal. This measurement is useful in determining the effect that a disturbance on an individual line has on a three-phase power circuit. Under and overvoltage disturbances are analyzed and recorded exactly the same way as the single phase measurements described in Section 1.2.2. No pulse disturbance is measured on the three-phase signal.

For accurate measurements, the three inputs must have the normal 120° phase separation. Phase sequence is not important.

1.2.4 PULSE MEASUREMENT

Three independent circuits are utilized to condition the AC phase voltages to extract the pulse information for analysis by the microprocessor. The attenuated inputs used for under/overvoltage measurements are also used for pulse measurement. The pulse circuitry includes a filter to remove the nominal line voltage so that the measurement is sensitive only to short pulses that deviate from the sinewave voltage. Figure 1-4 shows typical examples of the pulse measurement.

Since the data from the pulse circuitry is sampled by the microprocessor only every 30 milliseconds, capability is included in the analog conditioning circuitry to capture the parameters of very fast pulses and hold these values until the microprocessor can sample and store them. The analog conditioning does the following:

1. Samples and holds the peak amplitude of the highest amplitude pulse that occurs within each 30 millisecond time period.
2. Samples and holds the duration of the highest amplitude pulse that occurs within each 30 millisecond time period.
3. Determines whether the highest amplitude pulse adds to or subtracts from the line voltage (positive or negative pulse).

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Following the analog conditioning, the microprocessor does the following additional analysis:

1. Selects the highest amplitude pulse in a one-second time period and initiates a pulse disturbance printout with amplitude, duration, and sign.
2. Counts the number of one-second time intervals that pulses above threshold were recorded and places the number count into the Accumulator register.

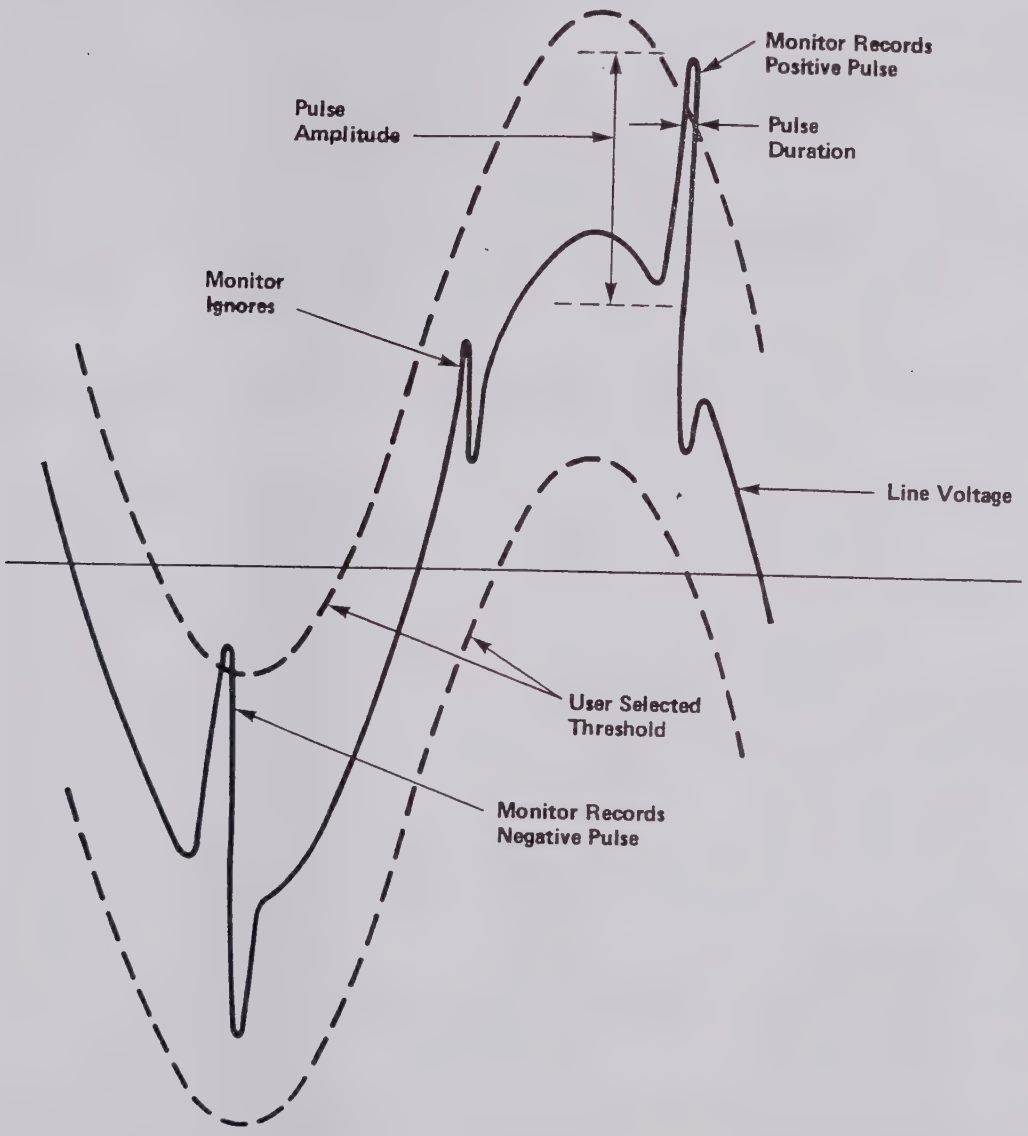


Figure 1-4. Pulse Measurement Waveforms

1.2.5 FREQUENCY MEASUREMENT

The signal from the Phase A input is applied to a frequency measurement circuit. The frequency measurement circuit operates continuously. However, if the level of the line voltage on Phase A falls below 50 VAC, the microprocessor will disable the frequency printout to prevent erroneous frequency deviation printouts for line levels that are too low for reliable measurement.

The frequency measurement circuit utilizes the internal crystal oscillator as a reference to generate a voltage precisely proportional to the input frequency. The voltage is filtered with an approximately 200-millisecond time constant and applied to the microprocessor. The microprocessor samples this voltage every 10 milliseconds, compares the level to the user-selected thresholds, and initiates an alarm if a threshold is exceeded. The maximum frequency error is also printed out each time a frequency disturbance is recorded.

1.2.6 DC MEASUREMENT

The DC input to the monitor is via a differential amplifier which provides accurate output for the level and pulse circuits. Two distinct measurements are made on the DC signal:

1. A level change that lasts long enough to pass through a 10-millisecond filter, and
2. Transients that are very fast compared to the 10-millisecond filter.

The level changes are recorded as high and low DC disturbances; the transients are recorded as DC pulses. The threshold settings for the DC input are the same for both level as well as pulse measurement. A DC disturbance will be recorded including the maximum deviation of the DC voltage during the disturbance. The pulse disturbance will be recorded without indication of amplitude. Pulse disturbances are recorded and accumulated at a maximum rate of once per second.

1.3 OPTIONS

A number of options for the Model 3600 Monitor are available. Special AC/DC combinations can be provided; several input combinations are available with the Model 3600L and Model 3600T; other options are listed in Section 9 of this manual.

1.4 DETAILED SPECIFICATIONS

The detailed specifications of the Model 3600 monitor are summarized below.

1.4.1 OVER/UNDER AC VOLTAGE MEASUREMENT

DYNAMIC INPUT RANGE: 50 to 800 VAC.

NOMINAL INPUT VOLTAGE: 100 to 600 VAC.

NOMINAL INPUT FREQUENCY: 50/60 Hz. 400 Hz optional.

ALARM INDICATION: An external Form-C contact is provided. Contact operates during any disturbance longer than 4 msec in duration and above threshold levels.

THRESHOLDS: Under and over voltage thresholds can be selected with the front panel keyboard. One threshold sets the level for all three inputs.

THRESHOLD RANGE: 50 to 800 VAC.

THRESHOLD ACCURACY: ± 1% of setting.

THRESHOLD PRINTOUT: Printout of threshold level included with status printout.

MEASUREMENT TYPE: Full wave rectification, average responding, RMS calibrated.

RESPONSE TIME: 10 millisecond time constant.

MEASUREMENT ACCURACY: ± 1% for 100 to 600 VAC input; ± 2% for 50 to 100 VAC input and for 600 to 800 VAC inputs.

OVER/UNDERVOLTAGE DURATION PRINTOUT: Duration of each alarm condition is printed out in milliseconds with 10-millisecond resolution up to 990 milliseconds. When disturbance lasts longer than 990 milliseconds, the time is printed out with ± 1 second accuracy.

HYSTERESIS: A hysteresis of approximately 1% of the selected threshold voltage is used to avoid excess printout when line voltage is very close to the threshold.

MEASUREMENT PRINTOUT: Printout of phase, type of disturbance and corresponding time whenever threshold is exceeded. During the time the threshold is exceeded, a new amplitude printout occurs every 30 seconds if the disturbance voltage varies by more than three percent of the threshold from the last printout. No voltage is produced if the voltage remains within three percent of the last printout.

THREE PHASE OVER/UNDERVOLTAGE MEASUREMENT: The three-phase undervoltage and overvoltage measurement may be selected during the SET mode. All three phases are full-wave rectified and summed. The same selected threshold voltages for individual phases are used. The specifications listed above apply to this additional measurement.

NUMBER OF ALARMS PRINTOUT: Status printout indicates number of over/undervoltage alarms printed and totalled for all three phases, up to a maximum of 900. At the total of 900, a status printout is made and the counter is reset.

1.4.2 PULSE MEASUREMENT

PULSE VOLTAGE RANGE: 50V to 1500V.

MEASUREMENT TYPE: Records either positive or negative pulses (with respect to sinewave) that exceed threshold setting with line voltage filtered out.

ACCURACY: ±10% for half sinewave pulses between 1 and 150 μsec duration. ±50% for half sinewave pulses between 0.3 μsec and 1 μsec and between 150 μsec and 1 msec.

THRESHOLDS: Pulse threshold can be selected with front panel keyboard. One threshold sets level for all three inputs.

THRESHOLD RANGE: 50V to 1500V.

THRESHOLD ACCURACY: ±1V.

THRESHOLD PRINTOUT: Pulse threshold voltage is printed out during Status printout.

PULSE AMPLITUDE PRINTOUT: Level of pulse in volts and phase on which disturbance occurred is printed.

PULSE POLARITY PRINTOUT: Printout indicates polarity (±) of pulse with respect to sinewave polarity.

PULSE DURATION: Duration of pulse is printed in microseconds with a resolution of ±1 microsecond up to 999 microseconds. When pulse disturbance lasts longer than 999 microseconds, the maximum number of 999 microseconds is printed.

RESPONSE TO MULTIPLE PULSE: When multiple pulses occur within a one-second interval, the magnitude, polarity and duration of the highest level pulse is recorded.

NUMBER OF ALARMS PRINTOUT: Status printout indicates number of pulse alarms printed, totalled for all three phases, up to a maximum of 900; at a total of 900, a *TOTAL DISTURBANCE* printout is made and the counter is reset.

1.4.3 FREQUENCY MEASUREMENT

FREQUENCY RANGE: 40 to 80 Hz. 400 Hz optional.

MEASUREMENT TYPE: A line frequency period measurement with a 200 msec time constant is made on Phase A.

THRESHOLD ACCURACY: ±0.1 Hz

THRESHOLD SETTING: Threshold can be set with 0.1 Hz resolution. A threshold for FREQ HIGH and FREQ LOW can be individually selected; a minimum of 0.3 Hz difference between thresholds must be chosen.

STATUS PRINTOUT: Frequency as well as HIGH and LOW threshold settings are printed out with Status printout.

MEASUREMENT PRINTOUT: Printout of FREQ HIGH or FREQ LOW together with time is printed whenever frequency exceeds the selected alarm band. Whenever frequency returns within the alarm bands, a line is printed with FREQ MIN or FREQ MAX together with value of maximum deviation and the time when a normal condition is measured.

HYSTERESIS: A hysteresis of 0.1 Hz is used to avoid excess printout when line frequency is very close to one of the two thresholds.

LOW LINE VOLTAGE: When the AC voltage on Phase A is less than 50V rms the frequency measurement is disabled.

1.4.4 DC MEASUREMENT

DC VOLTAGE RANGE: ±1 to ±22 VDC

THRESHOLD VOLTAGE RANGE: DC threshold high and low level selected with the front panel keyboard. Total range is from ±1 to ±22 VDC.

THRESHOLD ACCURACY: ±0.1V

AVERAGE MEASUREMENT ACCURACY: ±0.1V

MEASUREMENT PRINTOUT: When DC voltage exceeds either HIGH or LOW threshold limits, a printout of the time and DC HIGH or DC LOW is printed. Whenever the DC returns within the threshold limits, the value of the maximum excursion and time is printed.

PULSE MEASUREMENT: When a DC voltage pulse exceeds either the HIGH or LOW threshold limits, a printout of DC PULSE + or − and of the time is made. The minimum pulse amplitude must exceed the thresholds and the maximum pulse amplitude cannot exceed the maximum input voltage.

RESPONSE TIME: 1 μsec rise time for pulses and 10 msec time constant for average value.

HYSTERESIS: A hysteresis of 0.1V is provided to avoid excess printout when DC input voltage is very close to one of the two DC thresholds.

MAXIMUM INPUT VOLTAGE: ±50V maximum on either input to ground (sum of DC voltage + common mode voltage).

COMMON MODE REJECTION: Greater than 60 dB at 60 Hz; 40 dB at 1 MHz.

1.4.5 ADDITIONAL PRINTOUTS

EXTERNAL EVENT RECORDER: One external input can be connected. Detection of external contact closure results in printout of event with time of occurrence.

BATTERY CONDITION: If the AC line ... powers the monitor is too low, the inter UPS battery will power the monitor. A printout for ON BATTERY is given with the time. The monitor will operate ...h full capability in this mode for up to two hours. Actual time of battery operation depends on the current state of charge of the battery and the number of lines of print while on battery.

If operation on battery threatens to damage the battery by deep discharge, a battery protection circuit causes LOW BATTERY to be stored in memory and the monitor is automatically switched to STANDBY. Upon return of normal AC line voltage, if the battery has not been completely discharged, both the LOW BATTERY line with time and POWER ON line with time, are printed. The monitor will remain in this mode until the operator depresses the appropriate MEASUREMENT SELECT keys.

1.4.6 AC INPUTS

NUMBER OF INPUTS: 3 independent inputs marked A, B, C

TYPE OF INPUTS: Differential for line-to-line or line-to-neutral measurements

INPUT IMPEDANCE: 2M

1.4.7 DC INPUTS

NUMBER OF INPUTS: 1 separate input marked DC

TYPE OF INPUT: Differential

INPUT IMPEDANCE: 200K

1.4.8 ADDITIONAL FEATURES

EXTERNAL BATTERY: Spare contacts in the RS232 connector are provided for 12V batteries. One ampere-hour capacity will allow monitoring for two additional hours or more depending on printer activity.

ACCUMULATORS: The five different disturbances accumulated are under voltages, over voltages, Pulses, DC Voltage, and Frequency disturbances. The same type of disturbance is accumulated from all three phases up to 900. Printout is made either during STATUS PRINTOUT or when accumulator has reached 900.

CALIBRATION: The monitor Calibration Status can be verified at any time during normal operation by pressing the front panel CAL button.

Very stable and accurate internal sources provide signals that must result in printout within the specified accuracy.

PRINTER: A twenty column alphanumeric printer with a 5 × 7 dot matrix character format is used. Printer speed is approximately 2.5 lines/sec.

BUFFER STORAGE: Buffer storage of approximately 40 lines of data can be stored in memory for printout.

RS232 DIGITAL OUTPUT: All data that is printed out is available on a multi-pin RS232 digital interface connector for remote monitoring and recording. (Internal printer can be disabled to allow high speed data acquisition not limited by printer speed.)

TIME SYNCHRONIZATION: The time of day is normally synchronized to the AC line that powers the monitor. When the AC line goes down, the internal clock is timed with the internal crystal frequency. Crystal time accuracy is ± 10 seconds per day.

1.4.9 GENERAL SPECIFICATIONS

INPUT POWER: Single phase 120V ± 15% or 240V ± 15% switch selectable, 50/60 Hz, 30W max (400 Hz available from factory).

TEMPERATURE: + 10 to + 40°C.

WEIGHT: Less than 9.1 kg (20 lbs) including power cord, input cables, and manual.

SIZE: 12″ × 18″ × 7″ (L × W × H). Fits under most airline seats.

INTERNAL BATTERY: An internally charged battery allows up to two hours complete operation. Recharge time for full capacity is at least 24 hours.

FUSES: ½A slow-blow for AC input, 2A slow-blow for internal battery, 2A slow-blow for external battery.

SHIPPING WEIGHT: Less than 14.4 kg (32 lbs).

1.5 SUMMARIZED MEASUREMENT SPECIFICATIONS

Table 1-1 summarizes the input range, measurement accuracy, input impedance, threshold range, and response time of the parameters measured by the Model 3600 monitor.

Table 1-1. Measurement Specifications

	AC rms Line Voltage	3-Phase AC rms Line Voltage	Peak Pulse Voltage	Frequency	DC Voltage/ DC Pulse
Input Range	100 to 600V	50 to 800V	50 to 1500V	40 to 80.0 Hz	±1 to ±22V/ 50V maximum
Measurement Accuracy	± 1%	± 1% for 100 to 600V ± 2% for 50 to 100V and 600 to 800V	± 10% of level ± 5% of rms line voltage	± 0.1 Hz	± 0.1V
Input Impedance	2 MΩ	2 MΩ	2 MΩ	2 MΩ	200 KΩ
Threshold Range	50 to 800V in 1V steps	50 to 800V in 1V steps	50 to 1500V in 1V steps	40 to 80 Hz in 0.1 Hz steps	± 1 to ± 20V in 0.1V steps
Response Time	10 ms	10 ms	± 10% for half sinewave pulses between 1 and 150 μsec duration. ± 50% for half sinewave pulses between 0.3 μsec and 1 μsec and between 150 μsec and 1 msec.	200 ms	1 μs pulse 10 ms avg.

1.6 APPLICATIONS

A partial list of the applications of the monitor is provided below.

- Monitor disturbances on AC power mains
- Time-correlate equipment malfunction with disturbance occurrence
- Check power prior to installing sensitive equipment
- Field service
- Check UPS equipment during UPS and computer installation
- Monitor DC voltages on data processing and communications equipment
- Diagnosis of power system performance
- Design and production test instrument

1.7 SERVICE ASSISTANCE

Telephone assistance during normal working hours is available for monitor repairs and assistance. Call (408) 245-8900. The Telex number is 357-405. Franklin Electric also provides a circuit board exchange program. Franklin Electric has service centers located throughout the United States and in many countries throughout the world. Each service center has factory-trained personnel equipped to repair and recalibrate all Franklin Electric products.

1.8 STANDARD ACCESSORIES, OPTIONS, AND OPERATING SUPPLIES

Table 1-2 lists the standard accessories, options, and operating supplies available from Franklin Electric.

Table 1-2. Standard Accessories, Options, and Operating Supplies

DESCRIPTION	PART NUMBER
STANDARD ACCESSORIES	
Power Cord, 8 ft with 2-blade and ground plug	14-3400060
Single Phase AC Input Cable, 8 ft with alligator clip terminations (quantity of 3)	14-4230015
DC Monitor Connector	28-2000320
Key, SHH591 (quantity of 2)	—
Operator's Manual	74-0000311
OPTIONS	
DC Monitor Cable Assembly, 8 ft with alligator clip terminations	14-4230012
RS-232 Standard Interconnect Cable, 8 ft	14-4230013
RS-232 Cable Assembly, 8 ft with split out of special features	14-4230014
Single Phase AC Input Cable, 6 ft with standard 2-blade 115 VAC plug	14-4230016
Cable Assembly, Dual AC Power and Sense Input	14-4230021
400 Hz Analog Input Circuit Card	45-1799200
External DC Divider Assembly (2.5:1, 5:1, 10:1, and 25:1)	52-0000170
Combination of 60 Hz and 400 Hz AC Measurements	52-0000103
Carrying Case with Deeper Lid (3" total)	18-4000051
Service Manual	74-0000310
OPERATING SUPPLIES	
Printer Paper (3-roll package—blue print)	26-0100120
Printer Paper (3-roll package—black print)	26-0100121
Thermal Printer Head Cleaning Card	26-0100119

SECTION II
PREPARATION FOR USE

2.1 GENERAL

This section describes the contents of the power monitor shipping container. It also provides information about the general requirements for the use of the monitor.

2.2 INSPECTION

After unpacking the monitor, check that the following items are included:

- One power cable
- Two keys
- One Operator's Manual
- Any optional items you have ordered

Some monitors will be shipped with attached AC monitoring cables or terminal connections.

Check the serial number and special model number labels (located under the printer cover) against the Packing List and against your ordering data to be sure you have received the proper equipment. The serial number and special model number define the special software and special features ordered by specific customers.

The cables, manual and keys are stored in the monitor lid. The spare key should be placed in the clip in the top section of the case to prevent it from being misplaced. The Operator's Manual and the cables should be stored in the top section of the case when not in use to prevent loss or misplacement.

Please save the original packing material as this provides maximum protection for the monitor if it is necessary to ship by common carrier.

2.3 REQUIREMENTS FOR USE

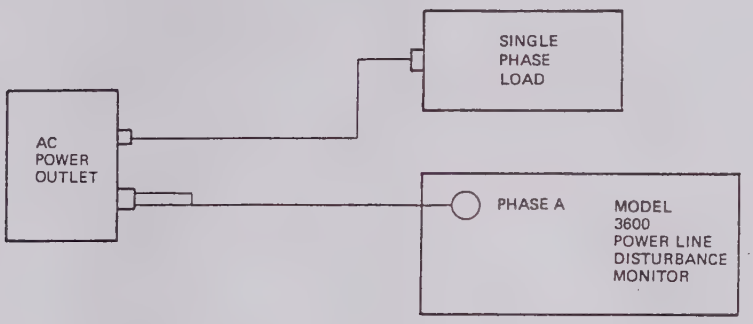
The monitor requires a nominal 120 VAC or 240 VAC single-phase power source for continuous operation. The monitor should be plugged into a grounded three-prong connector.

The monitor can be operated in any environment compatible with the operation of common electronic equipment. Operation or storage under conditions of extremely high or low humidity is not recommended. Operation in a corrosive atmosphere, such as salt-laden air, is also not recommended.

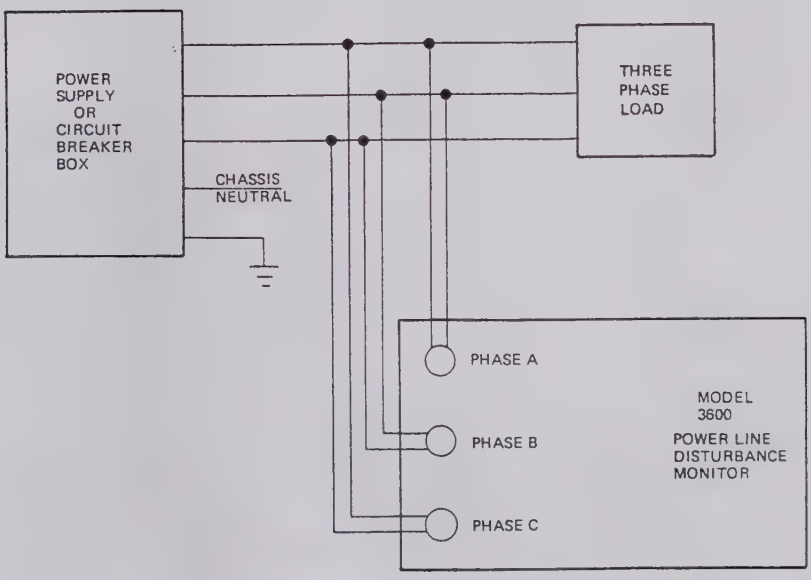
SECTION III
OPERATION

3.1 GENERAL

This section contains information about the operation of the monitor. Controls, indicators, and connectors are illustrated and described. Operating modes and measurement techniques are discussed. Input parameters and output displays are described and defined. Figure 3-1 shows typical test configurations using the monitor.



TYPICAL SINGLE PHASE TEST CONFIGURATION



TYPICAL THREE PHASE TEST CONFIGURATION

Figure 3-1. Typical Test Configurations

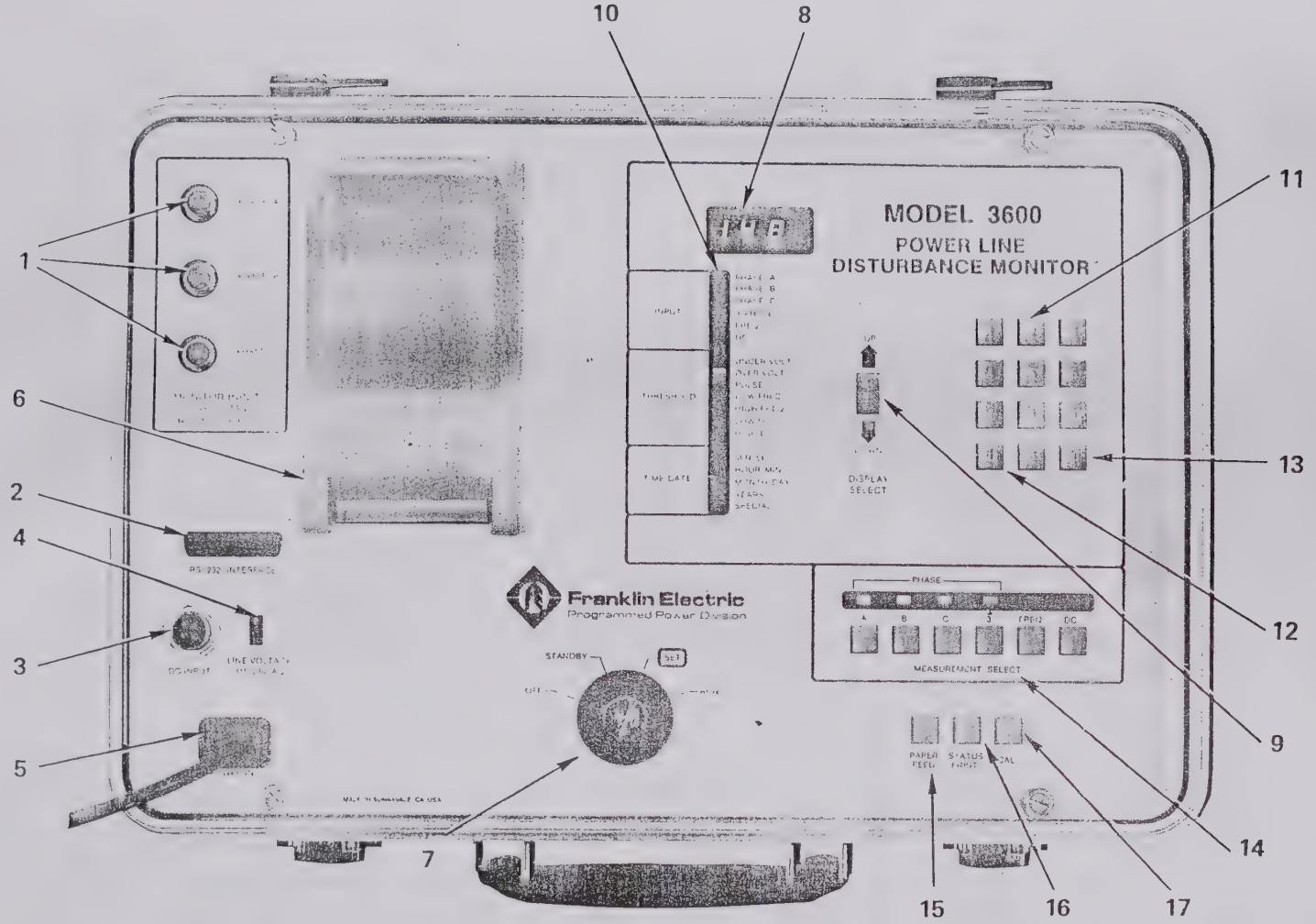


Figure 3-2. Connectors, Controls and Indicators (Description follows in Table 3-1)

3.2 CONNECTORS, CONTROLS AND INDICATORS

The monitor controls, indicators, and connectors are shown in Figure 3-2 and described in Table 3-1.

Table 3-1. Connectors, Controls and Indicators

INDEX	NOMENCLATURE	FUNCTION
1	MONITOR INPUTS PHASE A PHASE B PHASE C	Separate differential inputs for monitoring phase voltage, pulse, and frequency.
2	RS232 INTERFACE	Standard 25-pin RS-232 interface connector. Also includes remote event marker input, external alarm, and external battery input.
3	DC INPUT	Single differential input for monitoring DC voltage.
4	LINE VOLTAGE 120/240 AC	Selects line voltage used to operate the PLDM.
5	POWER IN	Input power connector.
6	Printer	20-column alphanumeric thermal printer.
7	Keylock Switch	Provides power control.
	OFF Position	In the OFF position, the unit is inoperable.
	STANDBY Position	In the STANDBY position, power is supplied to the internal memory and clock circuitry. The printer, displays, and all external controls are disabled. Parameters entered in the THRESHOLD fields remain valid. The STANDBY position allows the monitor to be moved without resetting the thresholds or the clock. Functions selected on the MEASUREMENT SELECT panel are cancelled. Parameter measurement is halted.
	SET Position	All controls are enabled when the switch is in this position. Note that data is collected when the key is in the SET position. In the SET position, the THRESHOLD and TIME/DATE parameters, and MEASUREMENT SELECT functions can be entered or modified.
	RUN Position	The RUN position provides a secure mode of operation. THRESHOLD and TIME/DATE parameters, and MEASUREMENT SELECT functions cannot be altered. No keyboard entries can be made. The PAPER FEED, STATUS PRINT, and CAL keys can be used when the key is in the RUN position.
8	LED Digital Display	A four-digit display. A decimal point is automatically inserted in frequency and DC inputs and measurements. Colons are automatically inserted between TIME/DATE fields. The colons are staggered (:).
9	DISPLAY SELECT Switch	The switch is used to position the light bar to the desired field.
10	Display Select Indicator	
	INPUT Fields	Positioning the light bar selects the input parameter to be displayed on the LED digital display.
	THRESHOLD Fields	Positioning the light bar selects the threshold to be entered on the keyboard or displayed on the LED digital display.
	TIME/DATE Fields	Positioning the light bar selects the Time/Date parameter to be entered on the keyboard or displayed on the LED digital display. The SPECIAL field allows the Data Accumulate mode or the Printer Turn-off command to be manually initiated from the keyboard.
11	Keyboard	Used to enter Threshold, Time/Date and Special parameters if keylock switch is in SET position.
12	CLR key	Clears Threshold, Time/Date and Special parameters selected by the position of the DISPLAY SELECT switch. Enabled only if the keylock switch is in SET position.
13	ENT key	Enters Threshold and Time/Date data into memory. Enabled only if the keylock switch is in SET position.
14	MEASUREMENT SELECT keys	Selects functions to be monitored (Phase A, Phase B, Phase C, 3 Phase, FREQ, DC).

Table 3-1. Connectors, Controls and Indicators (continued)

INDEX	NOMENCLATURE	FUNCTION
15	PAPER FEED key	Advances printer paper. Used to load a new roll of paper and to provide a leader.
16	STATUS PRINT key	Initiates status printout of all input levels, threshold settings, status accumulators, and time.
17	CAL key	Initiates internal calibrator and calibration printout. Depressing the key disconnects the inputs and initiates internally generated signals that are input to all internal measurement circuits. Calibration is verified with a printout that must show values within the calibration range.

3.3 SET-UP PROCEDURES AND CAL PRINTOUT

Simplified operating instructions are provided on the inside cover of the monitor. Refer to Figure 3-2 and Table 3-1 for the items shown in parentheses. Follow this procedure to set up the Model 3600 for operation.

1. Set the LINE VOLTAGE (4) to the rated voltage of the power main.

CAUTION

If the monitor is operated with the AC power cord removed, the external ground should be connected to the third wire of the AC input plug to avoid excessive common mode inputs. The third wire of the AC input plug is connected to the monitor chassis and to the circuitry ground.

2. Plug the power cord into the POWER IN receptacle (5). Plug the other end into the power main. Ensure that a grounded power socket is used.
3. Insert the key into the Keylock Switch (7), push down on the key, and turn it to the SET position. The operating parameters cannot be altered unless the key is in this position. The light bar in the Parameter Select Display (9) will be in the PHASE A position of the INPUT field.

CAUTION

Ensure that the paper supply in the printer is adequate before operating the monitor. Operating the printer without paper will damage the printer. Printer turn-off procedures are provided in paragraph 3.11. Paper installation procedure is located in paragraph 3.13.

4. Press the PAPER FEED key (15) to advance the paper.
5. Press the CAL key (17). CAL will be displayed on the LED Digital Display (8). Internally generated calibration signals verify that the monitoring circuits are operating correctly. A printout tape will be produced in five seconds, showing the values for each calibrated parameter. Figure 3-3 is a typical calibration printout and the acceptable range for each parameter. If the parameters for your monitor are not within the acceptable range, refer to the service assistance information in paragraph 1.7 of this manual. The acceptable range for each parameter is shown on the decal inside the monitor cover.
6. Refer to Figure 3-4 for the initial values that are displayed when the STATUS PRINT key (16) is pressed. Press the STATUS PRINT key (16). The INPUT values will all be zero because the monitor sensing leads have not yet been connected. The THRESHOLD SETTINGS are those written into memory at the factory. The TOTAL DISTURBANCES fields are all zero.

WARNING

Power mains can carry dangerously high voltage. Do not connect monitor leads to live mains. Always connect monitor leads to mains last. Disconnect monitor leads from mains first.

7. Plug a keyed sensing lead into PHASE A (1) connector until seated. A clicking sound verifies proper connection. DO NOT ATTEMPT TO ROTATE THE PLUG. BOTH THE PLUG AND THE JACK ARE KEYED.

NOTE

For other input configurations, e.g., Model 3600L or Model 3600T, see section 9.

8. Connect the sensing lead to the power source to be monitored.

*** CALIBRATION ***		ACCEPTABLE RANGE
Phase A	300 VAC	297 to 303
Phase B	300 VAC	297 to 303
Phase C	300 VAC	297 to 303
Phase A Pulse	595 Vpk	540 to 650
Phase B Pulse	595 Vpk	540 to 650
Phase C Pulse	595 Vpk	540 to 650
DC	10.0 VDC	9.9 to 10.1
Frequency	50.0Hz	49.9 to 50.1

****

Figure 3-3. Calibration Printout

INITIAL		TYPICAL	
****** STATUS ******		****** STATUS ******	
DATE	01-01-80	DATE	11-05-80
TIME	00:00:50	TIME	10:21:41
INPUTS		INPUTS	
PHASE A	0 Vac	PHASE A	118 Vac
PHASE B	0 Vac	PHASE B	118 Vac
PHASE C	0 Vac	PHASE C	118 Vac
3PH	0 Vac	3PH	119 Vac
DC	0.0 Vdc	DC	10.0 Vdc
FREQUENCY	0.0 Hz	FREQUENCY	60.1 Hz
THRESHOLD SETTINGS		THRESHOLD SETTINGS	
UNDER	50 Vac	UNDER	110 Vac
OVER	999 Vac	OVER	127 Vac
PULSE	100 Vpk	PULSE	50 Vpk
FREQ LOW	10.0 Hz	FREQ LOW	59.0 Hz
FREQ HIGH	99.9 Hz	FREQ HIGH	61.0 Hz
DC LOW	1.0 Vdc	DC LOW	9.5 Vdc
DC HIGH	25.0 Vdc	DC HIGH	10.5 Vdc
TOTAL DISTURBANCES		TOTAL DISTURBANCES	
UNDER	0	UNDER	29
OVER	0	OVER	28
PULSE	0	PULSE	238
DC	0	DC	5
FREQ	0	FREQ	1
3PH	0	3PH	10

****

Figure 3-4. Initial and Typical Status Printouts

3.4 ENTERING THRESHOLDS

The keylock switch must be in the SET position to enter operating parameters. Press the DISPLAY SELECT (10) to position the light bar to the desired parameter. The factory preset value will appear on the LED display. The factory preset values are permanently entered in the monitor memory and appear when the monitor is turned on. The parameters are entered on the keyboard (11) and appear on the LED display. Parameters entered on the keyboard are not entered in memory until the ENT key (13) is depressed or until the light bar is moved to the next position. An entry can be cleared by pressing the CLR key (12).

3.4.1 UNDER VOLT

An undervoltage is the lower voltage boundary you select as an alarm level. The monitor will accept threshold values from 50 VAC to 800 VAC in one-volt steps. When the light bar is positioned next to UNDER VOLT, the factory preset value of 50 will appear on the LED display. Enter the value you want and press the ENT key to lock the value in memory.

3.4.2 OVER VOLT

An overvoltage is the upper voltage boundary you select as an alarm level. The monitor will accept threshold values from 50 VAC to 800 VAC in one-volt steps. When the light bar is positioned next to OVER VOLT, the factory preset value of 999 will appear on the LED display. Enter the value you want and press the ENT key to lock the value in memory.

3.4.3 PULSE

A pulse is a subcycle voltage superimposed on the voltage sine wave. A pulse appears as a transient on the AC waveform. The monitor will accept pulse threshold values between 50 and 1500 volts in one-volt increments. When the light bar is positioned next to PULSE, the factory preset value of 100 will appear on the LED display. Enter the value you want and press the ENT key to lock the value in memory.

3.4.4 LOW FREQ

A low frequency is the lower frequency boundary you select as an alarm level. The monitor will measure any frequency between 40.0 Hz and 80.0 Hz in 0.1 Hz steps. When the light bar is positioned next to LOW FREQ, the factory preset value of 10.0 will appear on the LED display. Enter the three-digit value you want and press the ENT key to lock the value in memory. Note that the decimal point is always displayed.

3.4.5 HIGH FREQ

A high frequency is the upper frequency boundary you select as an alarm level. The monitor will measure any frequency between 40.0 Hz and 80.0 Hz in 0.1 Hz steps. When the light bar is positioned next to HIGH FREQ, the factory preset value of 99.9 will appear on the LED display. Enter the three-digit value you want and press the ENT key to lock the value in memory. Note that the decimal point is always displayed.

3.4.6 LOW DC

A low DC voltage is the lower voltage boundary you select as an alarm level. The monitor will measure DC voltage between 1.0 VDC and 20.0 VDC in 0.1 VDC steps. When the light bar is positioned next to LOW DC, the factory preset value of 01.0 will appear on the LED display. Enter the value you want and press the ENT key to lock the value in memory. Enter a leading zero for values under 10.0V. Note that the decimal point is always displayed.

3.4.7 HIGH DC

A high DC voltage is the upper voltage boundary you select as an alarm level. The monitor will measure DC voltage between 1.0 VDC and 20.0 VDC in 0.1 VDC steps. When the light bar is positioned next to HIGH DC, the factory preset value of 25.0 will appear on the LED display. Enter the value you want and press the ENT key to lock the value in memory. Enter a leading zero for values under 10.0V. Note that the decimal point is always displayed.

3.5 ENTERING TIME/DATE

The monitor uses a 24-hour clock in addition to providing year, month, and day information. The highest value that can be entered in the TIME fields is 23:59:59. The colons separating the hour minutes, and seconds are staggered (•'). The clock began running when you turned the monitor on. To alter this value, use a clock with a seconds display as a reference. The keylock switch must be in the SET position to enter time/date parameters. Press the DISPLAY SELECT switch (10) to position the light bar to the desired parameter. The unset internal clock time or a factory preset value will appear on the LED display. The factory preset values are permanently entered in the monitor memory and appear when the monitor is turned on. The unset internal clock time is the elapsed time from when the monitor was initially turned on. The parameters are entered on the keyboard (11) and appear on the LED display. Except for the MIN-SEC parameter setting, parameters entered on the keyboard are not entered in memory until the ENT key (13) is depressed. An entry can be cleared by pressing the CLR key (12).

3.5.1 MINUTES-SECONDS

Move the light bar to MIN-SEC. Select a minute and seconds value that is ahead of real time. Enter the first three characters of the time value you have selected. When real time equals the time value you have selected, enter the fourth digit. The last digit entered starts the clock. For example, if the time is 29:30 after the hour, enter 300. When the reference clock reaches 30:00, enter the last 0. The monitor is started and synchronized with real time to within one second. If you wish to change the value, press the CLR key and enter the new value.

3.5.2 HOURS

Move the light bar to HOUR-MIN. The minutes entered above will appear to the right of the colon. The minutes value cannot be altered or cleared if the light bar is in the HOUR-MIN position. Enter the hour value you have selected.

3.5.3 MONTH-DAY

Move the light bar to MONTH-DAY. A value of 01.01 will appear on the LED display. The two positions to the left of the decimal point indicate the month. The two positions to the right of the decimal point indicate the day. Enter the value you want.

3.5.4 YEARS

Move the light bar to YEARS. 1980 or 1981 will appear on the LED display. Enter the value you have selected.

NOTE

The SPECIAL field is used to manually enter the DATA ACCUMULATE mode. The field is also used to turn the printer off. This enables a faster data transmission rate through the RS232 interface output. These modes are discussed in paragraphs 3.8.4 and 3.11.

3.6 CHECKING THRESHOLDS

Press the STATUS PRINT (16) to obtain a status printout. Refer to Figure 3-4 for an example of the initial status printout. The DATE and TIME are those entered at the keyboard. The INPUT values are those of the power source to which the sensing leads are connected. The THRESHOLD SETTINGS are those entered at the keyboard. The TOTAL DISTURBANCES fields summarize the number of disturbances that have occurred since the monitor was turned on. The TOTAL DISTURBANCES fields should all be zero, because no measurements have been selected at the MEASUREMENT SELECT keys (14). The typical status printout that is displayed after the monitor has collected data is also shown in Figure 3-4.

3.7 MEASUREMENT SELECT

The MEASUREMENT SELECT keys allow you to choose the inputs to be monitored. If sensing leads are attached to the PHASE A, PHASE B, and PHASE C connectors on the MONITOR INPUTS panel, each of the inputs can be simultaneously monitored by pressing the associated key on the MEASUREMENT SELECT panel. A light bar will appear above each key that has been pressed. If the key is pressed a second time, the measurement selected will be cancelled.

Frequency measurement can be performed if the FREQ key is pressed and the PHASE A key is pressed. Frequency can be measured only from the PHASE A monitor input.

The front panel controls are scanned by the microprocessor every 0.4 seconds. Therefore, it is possible to depress a key for too short or too long a time. To obtain a feeling for the duration of the scan period, depress a key and observe the rate of selection and deselection.

If a MEASUREMENT SELECT key is held down, the light bar above it will blink at a 0.5-second rate.

Beginning at approximately S/N 900 the Front Panel Controls PCB will be changed to provide one data entry per key stroke.

3.8 DISTURBANCE PRINTOUTS

The disturbance printouts provide a printed record of the parameters that are above or below the thresholds previously selected. Refer to Figure 3-5. A TIME line is printed above the first disturbance of each hour. The second line shows on what phase the disturbance occurred, what the disturbance was, and when it happened. The third line shows the minimum value that was monitored. The time on the third line indicates when the voltage was again within the selected thresholds. The difference in time between the second and third lines indicates how long the disturbance lasted.

```
TIME                11:38:35
A   UNDER             38:35
A MIN      82V        38:38
```

Figure 3-5. Long Disturbance Printout

If an undervoltage or overvoltage lasts less than one second, the disturbance printout indicates the duration in milliseconds. The duration measurement has a 10-millisecond resolution. See Figure 3-6.

```
TIME                00:01:05
A   UNDER             01:05
A MIN    32V        870 mS
```

Figure 3-6. Medium Duration Disturbance

The second line shows that an undervoltage condition occurred on the Phase A sample and the time at which it occurred. The third line shows that the undervoltage dropped to a minimum of 32 volts and that it remained below the threshold for 870 milliseconds.

Pulses on the sampled voltage sine wave are measured in microseconds. Negative pulses subtract from the instantaneous voltage of the sine wave. Positive pulses add to the instantaneous voltage of the sine wave.

High amplitude, long duration negative pulses may indicate a temporary undervoltage condition. High amplitude, long duration positive pulses may indicate a temporary overvoltage condition. Refer to Figure 3-7. The first line indicates that a negative pulse occurred on the Phase A sample and the time at which it occurred. The second line indicates that the pulse had a value of 56 volts and that it lasted nine microseconds. The third line indicates that a positive pulse occurred on the Phase A sample and the time at which it occurred. The last line shows that the pulse had a value of 65 volts and that it lasted 24 microseconds.

```
A   PULSE –         42:58
A       56V          9 µS
A   PULSE +         49:35
A       65V         24 µS
```

Figure 3-7. Short Duration Disturbance

Frequency measurement can be made only on the PHASE A monitor input for line voltages above 50 VAC RMS. To measure frequency, press the FREQ key on the MEASUREMENT SELECT panel. See Figure 3-8. The first line indicates that the frequency went above the HIGH FREQ threshold and the time at which this occurred. The second line shows that the frequency reached a maximum value of 69.4 Hz. It also shows the time the frequency went below the previously selected HIGH FREQ threshold. The third line shows that the frequency went below the LOW FREQ threshold and the time at which this occurred. The fourth line shows that the frequency reached a minimum value of 51.3 Hz and that the frequency remained below the LOW FREQ threshold for 390 milliseconds.

```
FREQ HIGH          00:47
FREQ  MAX 69.4     00:51
FREQ  LOW          00:59
FREQ  MIN 51.3  390 mS
```

Figure 3-8. Frequency Measurement

3.8.1 POST THRESHOLD TRACKING

Post Threshold Tracking is a new measurement technique for power line monitoring. A voltage exceeding a selected threshold is automatically tracked for the entire period that it exceeds the threshold. The voltage is still sampled every 10 milliseconds. A new amplitude printout occurs every 30 seconds if the disturbance voltage varies by more than three percent of the undervoltage threshold from the last printout. Exact levels and times of occurrence permit close tracking of the disturbance whether it is of short or long duration. The undervoltage threshold for a 105 volt line is approximately 3 volts. No printout is produced if the voltage remains within ±3 volts of the last printout. Refer to Figure 3-9. The second line indicates that an undervoltage condition has occurred. The third line shows that post threshold tracking is occurring and that the voltage has reached a level of 97 volts. The fourth line shows that post threshold tracking is still taking place and that the voltage has reached a level of 86 volts. Note that each voltage varies by more than plus or minus three percent of the undervoltage threshold from the previous printout and that the time has changed by 30 seconds.

```
TIME               00:01:21
A   UNDER            01:21
A LEVEL  97V         01:51
A LEVEL  86V         02:21
A LEVEL  94V         02:51
A LEVEL  87V         03:21
```

Figure 3-9. Post Threshold Tracking

3.8.2 TOTAL DISTURBANCES

A status printout can be initiated by pressing the STATUS PRINT key. Refer to Figure 3-10. The INPUT values are those of the power mains to which the sensing leads are connected. The THRESHOLD SETTINGS are those entered at the keyboard. The TOTAL DISTURBANCES values summarize the type and number of disturbances that have occurred since the monitor was turned on. If the total number of disturbances equals 900 or more, a TOTAL DISTURBANCES printout of eight lines will be automatically initiated and all of the disturbance counters will be reset to zero. The rollover TOTAL DISTURBANCES heading begins and ends with asterisks (*TOTAL DISTURBANCES*). A status printout will also be automatically initiated when the clock reaches midnight.

If a number of different tests are to be run on the same day, it is possible to obtain the TOTAL DISTURBANCES for each test with the STATUS printout. Resetting of all the accumulators is achieved by moving the keylock switch from RUN or SET to STANDBY. Returning the keylock switch to SET or RUN readies the monitor for the next set of measurements. Reselect the desired measurements.

```
****** STATUS ******
DATE              11-05-80
TIME              10:21:41
        INPUTS
PHASE A          118 VAC
PHASE B          118 VAC
PHASE C          118 VAC
3PH              119 VAC
DC                 0.0 VDC
FREQUENCY         60.1  Hz
  THRESHOLD SETTINGS
UNDER            110 VAC
OVER             127 VAC
PULSE             50 Vpk
FREQ LOW          59.0  Hz
FREQ HIGH         61.0  Hz
DC LOW            11.4 VDC
DC HIGH           12.6 VDC
  TOTAL DISTURBANCES
UNDER                29
OVER                 28
PULSE               238
DC                    0
FREQ                  0
3PH                   0
**********************
```

Figure 3-10. Status Printout

3.8.3 DATA OVERLOAD

Refer to Figure 3-11. If data activity exceeds the capacity of the printer, up to 40 lines of data are stored in memory for later printout. If data activity exceeds the memory capacity, a DATA OVERLOAD mode is initiated. During the DATA OVERLOAD mode, the maximum voltage excursions of all monitored and selected inputs are updated and stored in a special memory. When the printer is again able to keep up with data activity, the maximum and minimum disturbance values are printed. The DATA NORMAL line is then printed, indicating that the normal mode of operation has resumed. Note that even during DATA OVERLOAD mode, all disturbances are counted in the accumulators in the same manner as in normal operation. Therefore, if a STATUS printout is requested, it will indicate a full count of all disturbances that have occurred since the monitor was turned on.

```
DATA OVERLOAD    37:23
A MIN              18V
A MAX             142V
3PH  MAX          134V
C PULSE           625V
DATA NORMAL      38:39
```

Figure 3-11. Data Overload

3.8.4 DATA ACCUMULATE MODE

Refer to Figure 3-12. If the data activity exceeds 50 disturbances a minute for 10 consecutive minutes, the DATA ACCUMULATE mode is automatically initiated. In this mode, the printer stops and the monitor stores the maximum and minimum deviations from the preset thresholds. If three or fewer disturbances are received in 10 seconds for five consecutive samples in one minute, the DATA ACCUMULATE mode is automatically cancelled and the printer is enabled. The stored maximum and minimum values are then printed.

DATA ACCUMULATE

TIME	10:24:55
C MIN	60V
B MAX	138V
A PULSE	635V
DATA NORMAL	26:08

Figure 3-12. Data Accumulate

The DATA ACCUMULATE mode can be manually initiated. Turn the Keylock Switch to the SET position. Move the Parameter Select Display light bar to the SPECIAL position. Enter "01" on the keyboard. The LED Display will show "0.1." The DATA ACCUMULATE mode can be cancelled by moving the light bar to the SPECIAL position and pressing the CLR key on the keyboard.

The manually entered DATA ACCUMULATE mode can be used for long-term monitoring when no interim printout is required. When the DATA ACCUMULATE mode is cancelled, the total number of disturbances can be obtained by pressing the STATUS PRINT key.

Note that the TOTAL DISTURBANCES printout is automatically printed if more than 900 disturbances occur. The midnight STATUS printout takes place automatically and the CAL and STATUS printout can still be initiated from the front panel.

3.9 THREE-PHASE MEASUREMENT

Three-phase measurements are made with the same thresholds used to monitor the single phase inputs. The AC voltages of three phases with 120-degree phase shift are full-wave rectified and summed. Three-phase measurement requires that sensing leads be plugged into the PHASE A, PHASE B, and PHASE C connectors on the MONITOR INPUT panel and connected to three-phase power with normal 120 degree phase displacement. All three phases have differential inputs that are not polarity sensitive.

To measure three-phase power, press the 3 PHASE key on the MEASUREMENT SELECT panel. A light bar above 3 PHASE key indicates that three-phase power is being monitored.

PHASE A, PHASE B and PHASE C can be monitored individually if the appropriate key on the MEASUREMENT SELECT panel is pressed. However, three-phase measurement does not require that any of the individual phases be selected.

NOTE

If the three AC voltage input sensing leads are connected to one source, an instability of several percent will appear on the three-phase display. This error is due to added ripple because the rectifier is responding to a single phase instead of a three-phase signal.

Figure 3-13 shows a typical three-phase printer output.

WARNING

Power mains carry high voltage. Injury or death may result upon contact.

```
A MAX      140V     02:28
B MAX      143V     02:28
C MAX      141V     02:28
3PH   MAX 141V     02:28
```

Figure 3-13. Three-Phase Printout

3.9.1 WYE CONFIGURATION FOR THREE-PHASE MEASUREMENT

Refer to Figure 3-14. To connect the power monitor leads in a wye configuration to the power source, follow this procedure:

1. Connect one wire of each voltage sensing cable to neutral (N).
2. Connect the remaining wire of each voltage sensing cable to the corresponding phase to be monitored. Note that there is no voltage polarity sensitivity.

3.9.2 DELTA CONFIGURATION FOR THREE-PHASE MEASUREMENT

Refer to Figure 3-15. To connect the power monitor leads in a delta configuration to the power source, follow this procedure:

1. Connect the two leads of the PHASE A voltage sensing cable to Phase A and Phase B of the source to be monitored.
2. Connect the two leads of the PHASE B voltage sensing cable to Phase B and Phase C of the source to be monitored.
3. Connect the two leads of the PHASE C voltage sensing cable to Phase C and Phase A of the source to be monitored.

3.10 DC MEASUREMENT

The power monitor can simultaneously monitor one DC input and three AC inputs. The independent DC channel has an operating range of ± 20 VDC or higher with an external attenuator. The input impedance of the DC channel is 200K ohms differential. A printout will be produced whenever the DC key on the MEASUREMENT SELECT panel is pressed.

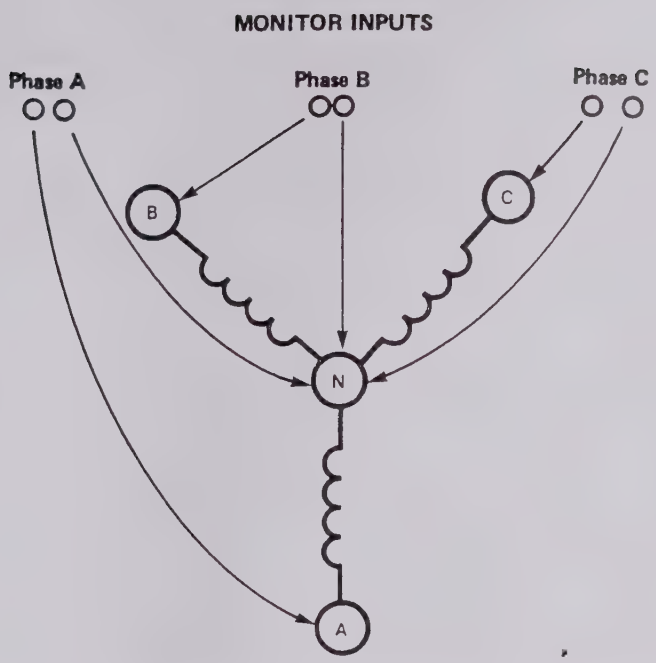
The third wire of the DC channel is connected to the monitor signal ground, which is also connected to the front panel and to the third ground lead of the AC power connector. The maximum range of operation of the DC input is 20 VDC. However, the unit will accommodate up to 50 VDC differential, including common mode, with respect to the ground lead and still operate within specification.

CAUTION

Because the AC third wire ground, the monitor front panel, and the DC channel ground connector are all electrically connected together, do not attempt to connect the DC channel ground to other than the earth or chassis ground to which the AC third wire is connected.

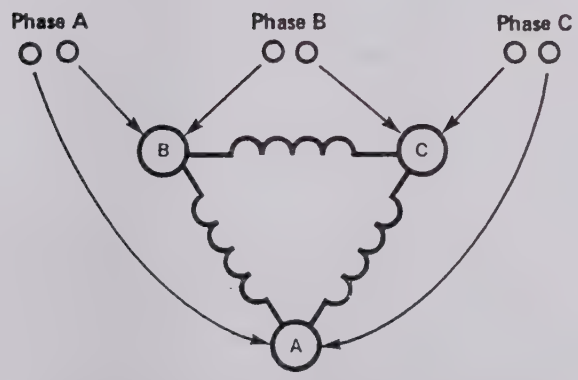
Damage to the DC input circuitry will occur if voltages in excess of 100 volts are applied.

To measure DC levels greater than 20 VDC, the inputs must be attenuated to fall within the 20 VDC range. Franklin Electric offers an External DC Attenuator (P/N 520000170), which provides accurate attenuation of 2.5, 5, 10, and 25 to enable measurement of voltages up to 500 VDC. Figure 3-16 shows the proper connection of the DC input cables.



Note that the monitor input cables are not polarized.

Figure 3-14. WYE Connection



Note that the monitor input cables are not polarized.

Figure 3-15. Delta Connection

	POSITIVE VOLTAGE	CONNECTOR PIN NO.
Positive Voltage	Red lead	4
Ground (or negative voltage)	Black lead	1
Chassis (earth ground)	Yellow lead	3
	NEGATIVE VOLTAGE	
Negative Voltage	Black lead	1
Ground (or positive voltage)	Red lead	4
Chassis (earth ground)	Yellow lead	3

Figure 3-16. DC Input Cable Connection

The DC voltage display and the DC LOW and the DC HIGH thresholds have to be multiplied by the same ratio as that of the External DC Attenuator.

To connect the DC sensing cable to the power source, follow this procedure:

1. Connect the DC input cable to the DC INPUT receptacle.
2. Connect the RED clip of the DC input cable to the most positive voltage.
3. Connect the BLACK clip of the DC input cable to the most negative voltage.
4. Connect the YELLOW clip of the DC input cable to chassis ground.

The DC input voltage is sampled every 10 milliseconds. A disturbance with a duration greater than 10 milliseconds is an undervoltage or an overvoltage. A disturbance with a duration less than 10 milliseconds is a pulse. Refer to Figure 3-17. The DC PULSE printout indicates the time and polarity of the occurrence that exceeded the preset thresholds. The DC PULSE printout occurs only once a second.

```
DC HIGH          01:29
DC MAX 10.6V   750 mS
DC  PULSE –      01:31
DC  LOW          01:32
DC MIN  8.9V   790 mS
```

Figure 3-17. DC Measurement

3.11 RS232 INTERFACE

The 25-pin RS232 INTERFACE connector on the front panel of the monitor is used to connect an RS232 compatible device to the monitor. Not all of the pins are required for the RS232 interface. One pair of pins is used to input +12 volts from an external battery. Another pair of pins is used to input a +5 to +28 volt external time mark to the monitor. Three other pins are relay contacts used for external alarm indicators. Table 3-2 provides the interface pin assignments of the Standard RS232 Cable Assembly, P/N 144230013, and the special RS232 cable, P/N 144230014, which includes the standard RS232 functions and the external RS232 functions. The detailed specifications and timing diagrams for the RS232 interface are defined in the EIA RS232 Standard Manual.

The monitor has the capability of outputting data separately to:

1. The thermal printer mounted to the front panel. The data rate is 2.5 lines per second for a 20-character-wide line.
2. An externally connected RS232 interface device with matching characteristics.
3. The printer and RS232 interface simultaneously.

When a fast interface device and the relatively slow thermal printer are used at the same time, the rate of the printer controls the rate of transmission by recognizing the Carriage Return (CR) and Line Feed (LF) characters at the end of each line. Data is output upon completion of a completely assembled 20-character line, as long as assembled lines are available.

Table 3-2. RS232 Interface Pin Assignments

PIN NO.	FUNCTION	WIRE COLOR	CABLE
2	Transmitted Data	Black	Standard RS232 Cable Assembly
3	Received Data	White	
4	Request to Send	Red	
5	Clear to Send	Green	
6	Data Set Ready	Brown	
7	Signal Ground	Blue	
8	Received Line Signal Detect	Orange	
11	External Status	Yellow	
20	Data Terminal Ready	Purple	
9	+12V External Battery (+13.9 float to +10V min)	Red	External Function RS232 Cable Assembly
10	Battery Ground	Black	
12	Relay Contact (COM)	Green	
13	Relay Contact (N.C.)	Blue	
14	Relay Contact (N.O.)	Orange	
24	+ Ext. Time Mark (+5V to +28V)	Brown	
25	– Ext. Time Mark	White	

To turn the thermal printer off, move the light bar to the SPECIAL field on the display panel. Enter 10. To turn the thermal printer back on, enter 00 via the SPECIAL field. Note that the decimal is always displayed. Data is outputted on pin 3 of the connector. The unused pins of the standard data terminal interface, pins 5, 6 and 8, are held high through 22K ohms to +18V.

The specifications of the RS232 interface are listed below.

1. Standard Interface—RS232, data terminals only, no 20 mA current loop.
2. Data Transmission Rates—Standard speed is 9600 baud. Other baud rates available are 4800, 2400, 1200, 600, 300, and 150. A seven-switch DIP, located on the Front Panel Controls PCB assembly (see Figure 5-6 for location), is factory set and shipped with switch 1 in the "on" position, which selects a 9600 baud rate. Other switches select the following baud rates: 2-4800 baud, 3-2400 baud, 4-1200 baud, 5-600 baud, 6-300 baud, 7-150 baud. Note that one and only one of the seven switches can be set to "on" at any time; otherwise the interface will not operate.
3. Character Format—The standard Model 3600 contains all upper and lower case ASCII characters.
4. Word Format—11 bit word—one START bit, seven data bits, one parity bit, and two STOP bits.
5. Cable Length—The cable can be up to eight feet long.
6. Current Output—Source or sink no more than one TTL load.
7. Serial data is transmitted in blocks of ASCII characters; at the end of each block an EOT code is inserted.

The EXTERNAL TIME MARK feature allows the time correlation of AC line disturbances and contact closure or opening, such as the turn-off of equipment on over-temperature detection. External circuitry must supply +5 to +28V at pin 24. The input impedance of this terminal is 4.7K ohms.

The external battery interface requires a battery with a nominal voltage of +12 volts and a float voltage of +14.5 volts. A charge capability limited to 1A is available if the AC line is providing the power to the monitor. If too much charging current is required, the Battery Low voltage condition is detected by the monitor. The monitor automatically switches to the Standby mode. The external battery input has a 2-ampere slow-blow fuse located under the front panel.

The external relay contacts can be used for several applications, such as remote audio or visual alarms and system shutdowns. The relay contacts are rated at 2 amperes at +28 VDC and 0.5 amperes at 120 VAC. Maximum contact resistance is 0.1 ohms. The relay remains closed for the duration of the disturbance.

3.12 UNINTERRUPTIBLE POWER SUPPLY (UPS) OPERATION

BATTERY CONDITION: If the AC line that powers the monitor is too low, the internal UPS battery will power the monitor. A printout for ON BATTERY is given with the time. The monitor will operate with full capability in this mode for up to two hours. Actual time of battery operation depends on the current state of charge of the battery and the number of lines of print while on battery.

If operation on battery threatens to damage the battery by deep discharge, a battery protection circuit causes LOW BATTERY to be stored in memory and the monitor is automatically switched to STANDBY. Upon return of normal AC line voltage, if the battery has not been completely discharged, both the LOW BATTERY line with time and POWER ON line with time, are printed. The monitor will remain in this mode until the operator depresses the appropriate MEASUREMENT SELECT keys.

3.13 PAPER INSTALLATION PROCEDURE

CAUTION

Operating the printer without paper will damage the printheads. To turn the printer off, refer to paragraph 3.11.

The end of the paper roll is indicated by a colored strip on the side of the paper, starting approximately ten yards from the end. To change the paper, proceed as follows:

1. Raise the plastic printer cover.
2. Remove the plastic spindle from the printer assembly and remove the empty paper core from the spindle.
3. Prior to inserting new roll of paper, clean the printheads by running the hard paper cleaning strip through the printer while pressing the PAPER FEED button.
4. Insert spindle in new roll of paper and insert roll in printer assembly with paper feeding from the bottom. Be sure spindle snaps into place.
5. While pressing the PAPER FEED button, guide the paper under the rubber roller (platen).
6. To be sure the paper is running perpendicular to the platen, depress the PAPER FEED button and allow a few feet of paper to run through while observing that paper doesn't rub against either side of the printer assembly. Align as necessary.

CAUTION

If not installed properly, the paper will bind around platen edges during unattended operation and eventually burn out the printhead. Correct operation of the printer is guaranteed only if factory approved thermal paper is used.

7. Lower the plastic printer cover and snap in place.

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